PRIMARY VARIABLES WHICH CAUSE SOME COMMON SCALES IN SALINE WATER SYSTEMS

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The ERDA Energy Research Center in Bartlesville, Okla., has studied the primary variables that can cause scales to form in oilfield water systems and to relate how similar scales could form in a geothermal brine system. Most of the variables contribute in the formation of more than one type of scale. The common scales, with special emphasis on barium sulfate, and silica scales, will be discussed.

There are many scales that can form from water systems; however, in saline oilfield water systems the common scales are few. These common scales are calcite ($CaCO_3$), gypsum ($CaSO_4 \cdot 2H_2O$), anhydrite ($CaSO_4$), strontium sulfate ($SrSO_4$), ferrous carbonate ($FeCO_3$), ferrous sulfide (FeS), ferrous hydroxide ($Fe(OH)_2$), ferric hydroxide ($Fe(OH)_3$), and ferric oxide (Fe_2O_3). In saline geothermal water systems, scales form which often are mixtures of nearly amorphous clay minerals of the chlorite or serpentine families, α-quartz, chert (microcrystalline quartz) and anhydrite.

The primary variables that cause, or prevent, scale formation are temperature, total dissolved salts, pH, pressure, partial pressure of CO_2, dissolved gases, and corrosion.

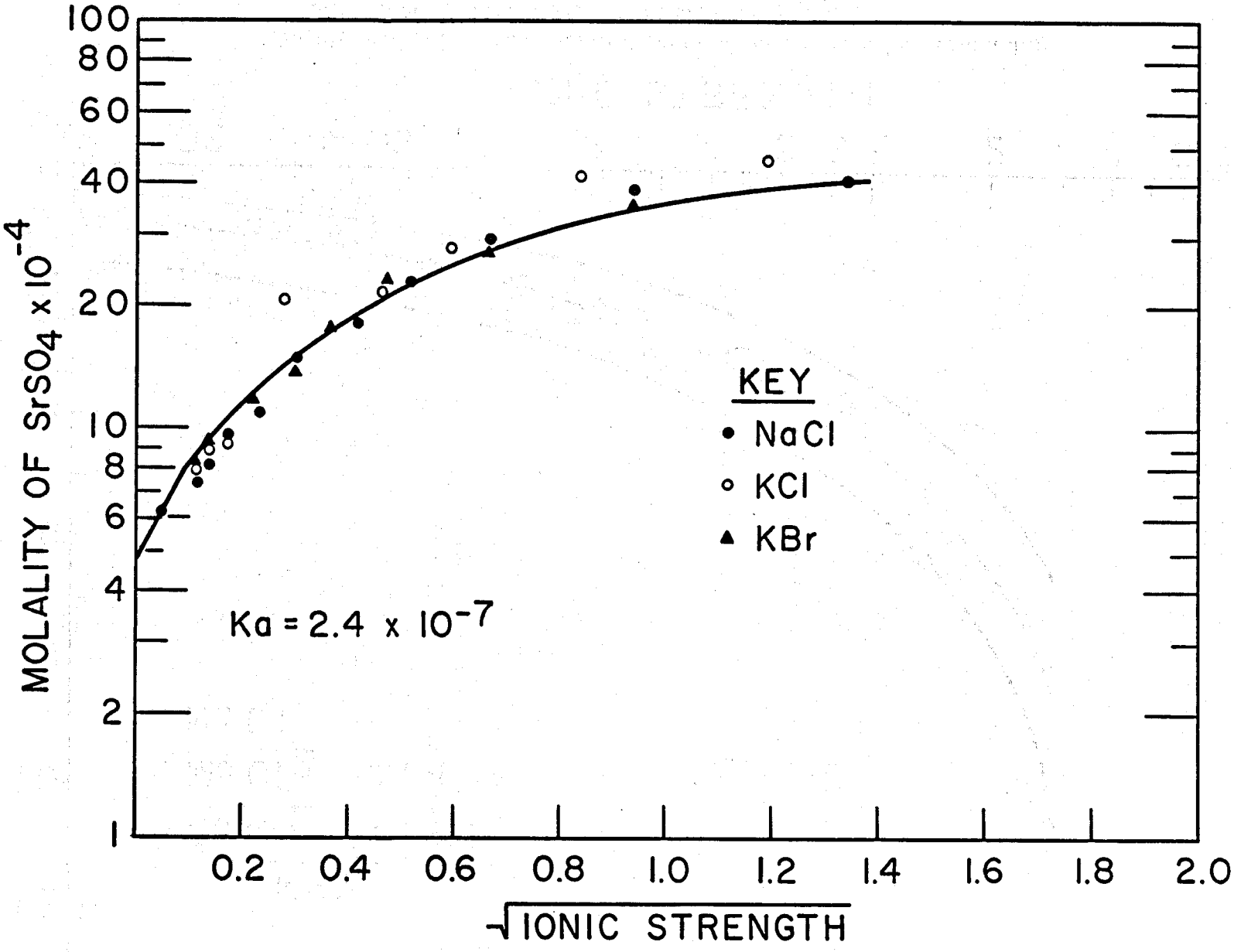
DISCLAIMER

Table 3

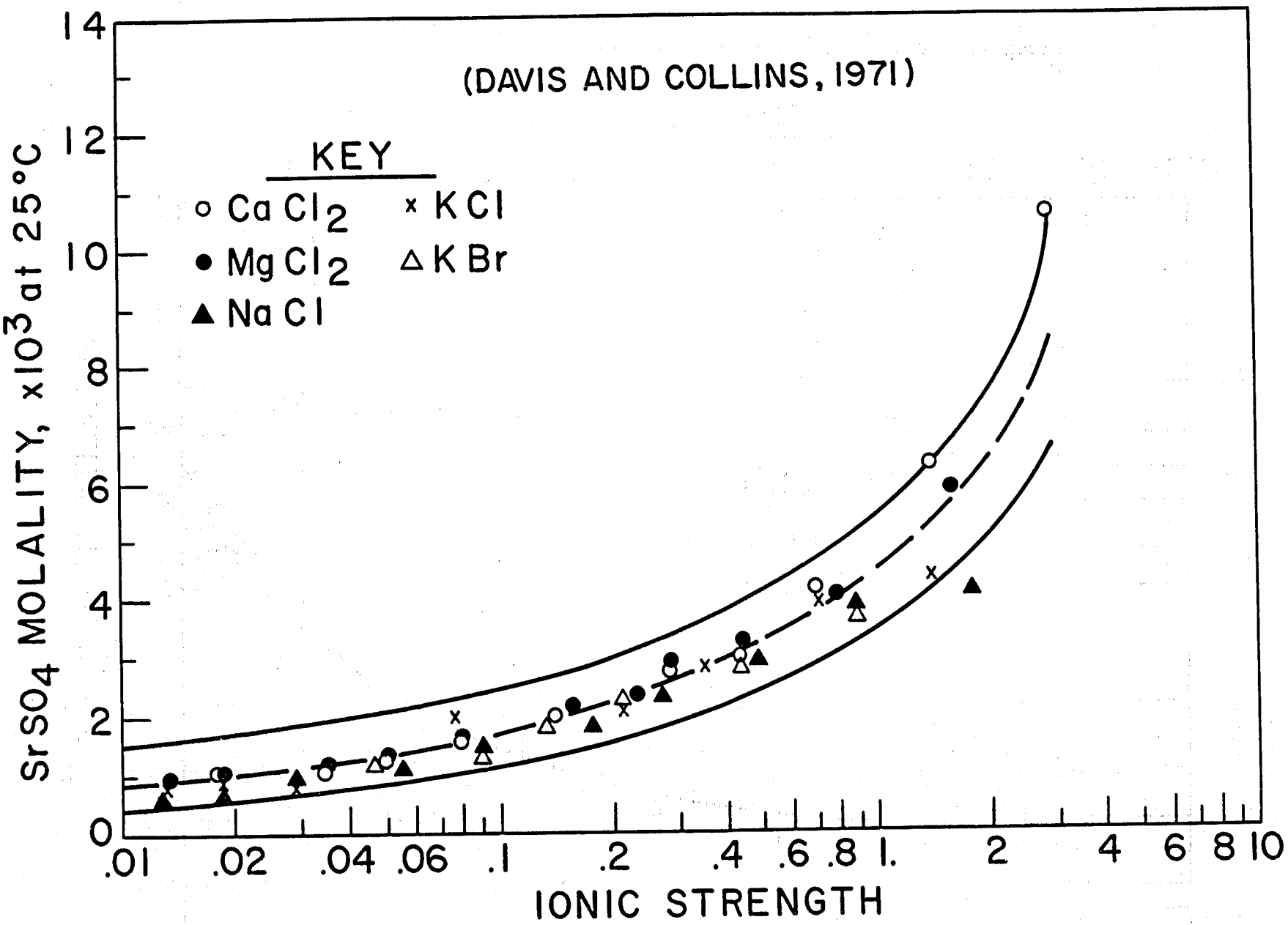
Composition of a brine that does not contain a stoichiometric combining weight ratio of strontium and sulfate*

Ion	mg/l	me/l	Molality
Na^{+}	49,000	2,130	2.24
K^{+}	220	6	0.00589
Ca^{+2}	11,500	574	0.303
Mg^{+2}	2,400	197	0.104
Ba^{+2}	25	< 1	0.00018
Sr^{+2}	1,000	23	0.012
Fe^{+2}	101	4	0.00189
Cl^{-}	106,140	2,990	3.15
SO_4^{-2}	170	4	0.00189
Total	170,556		

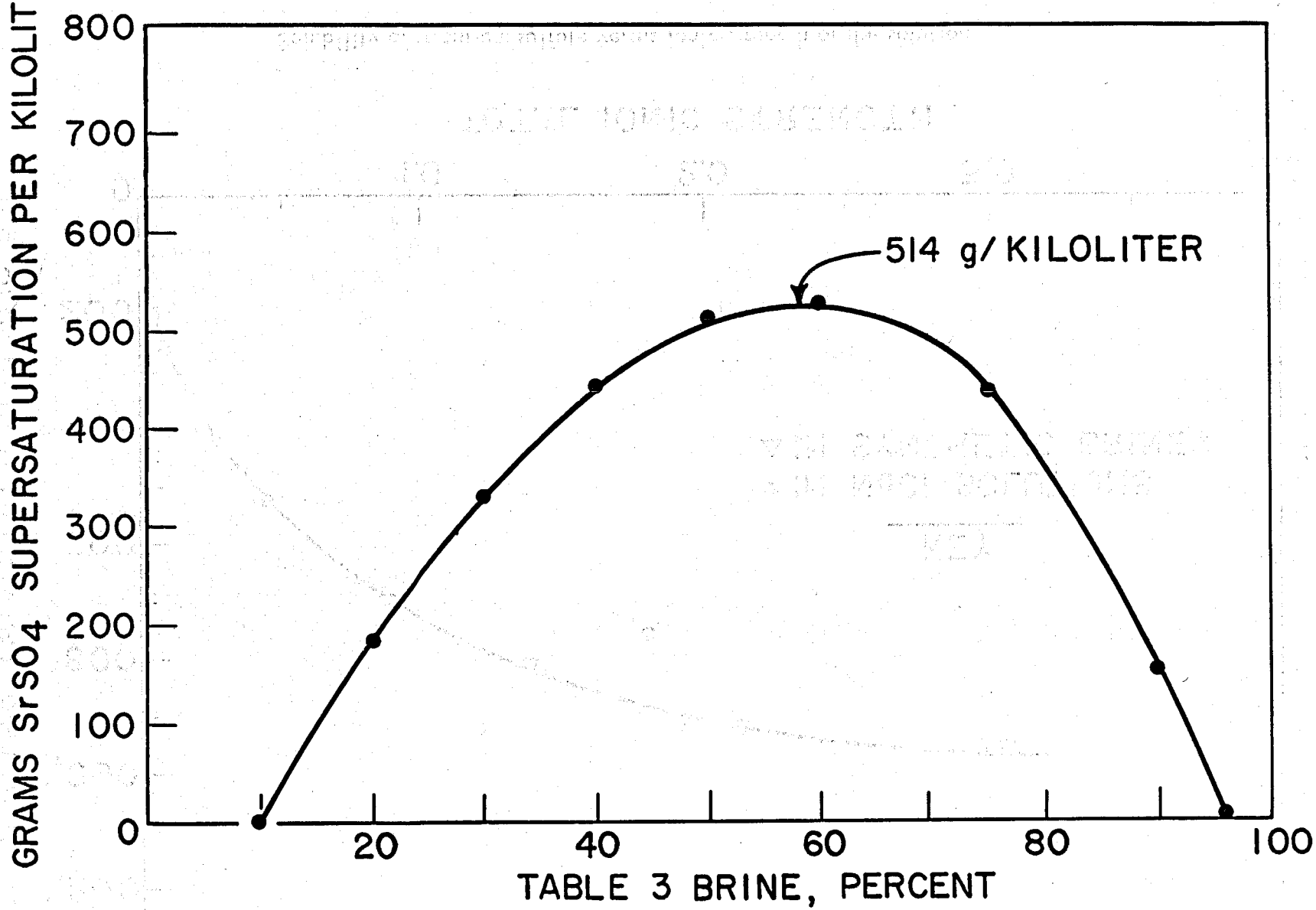
*Total ionic strength = 3.54; density at 22°C = 1,120 g/l; grams H_2O/l = 950.



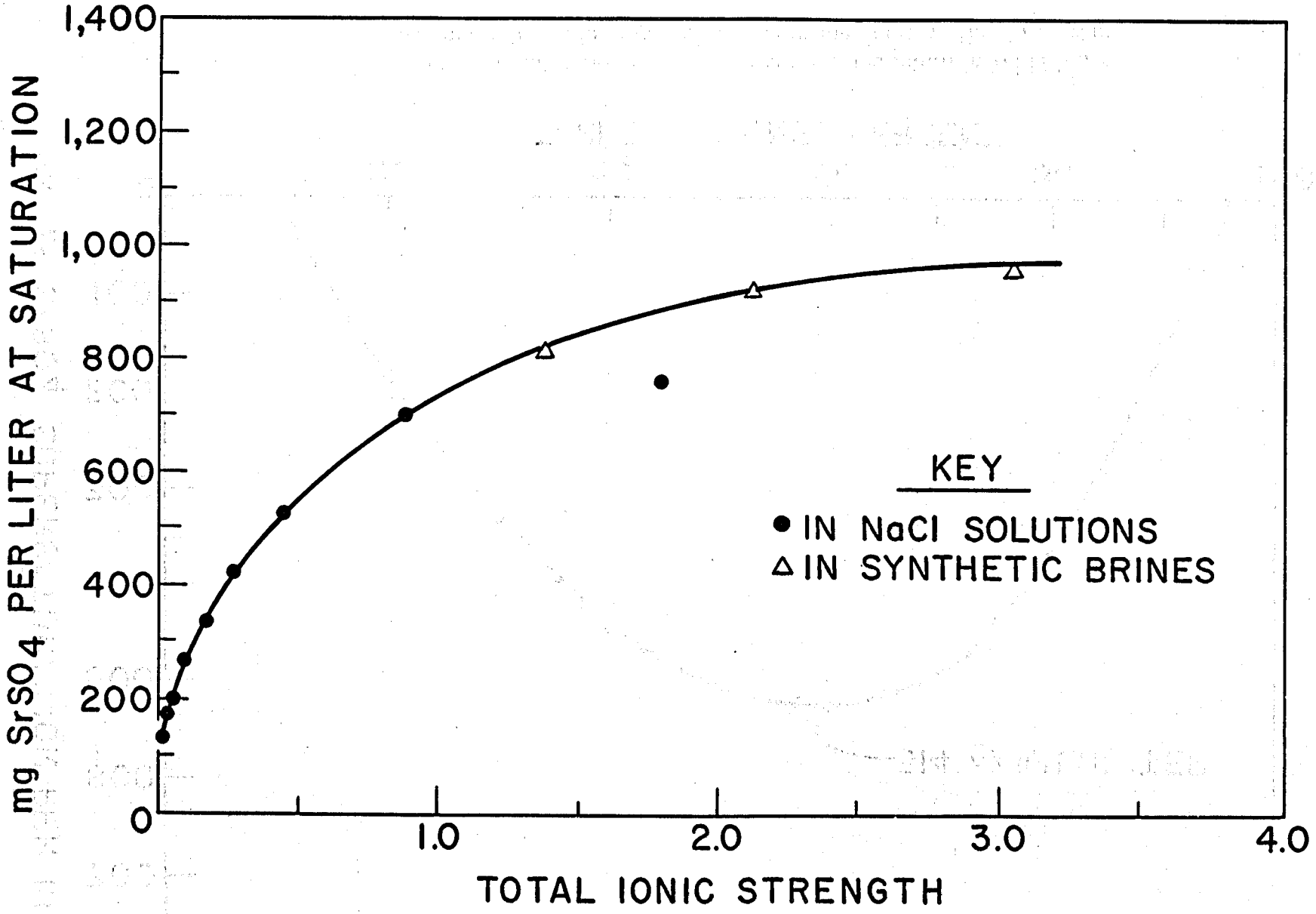
Concentrations of saturated $SrSO_4$ in strong electrolyte solutions of NaCl, KCl, and KBr.



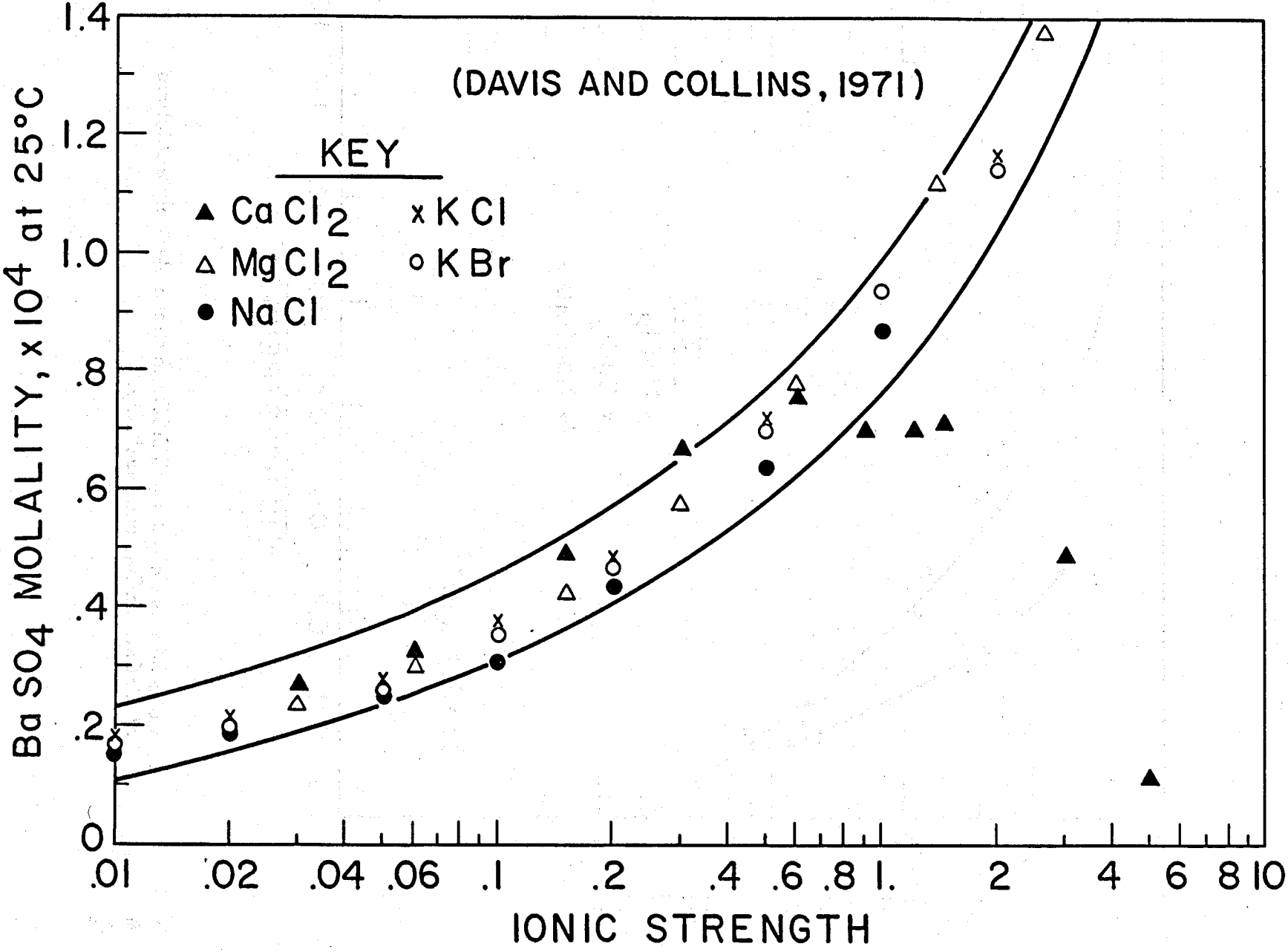
Solubility of $SrSO_4$ versus ionic strength of aqueous solutions containing $CaCl_2$, $MgCl_2$, NaCl, KCl, and KBr.



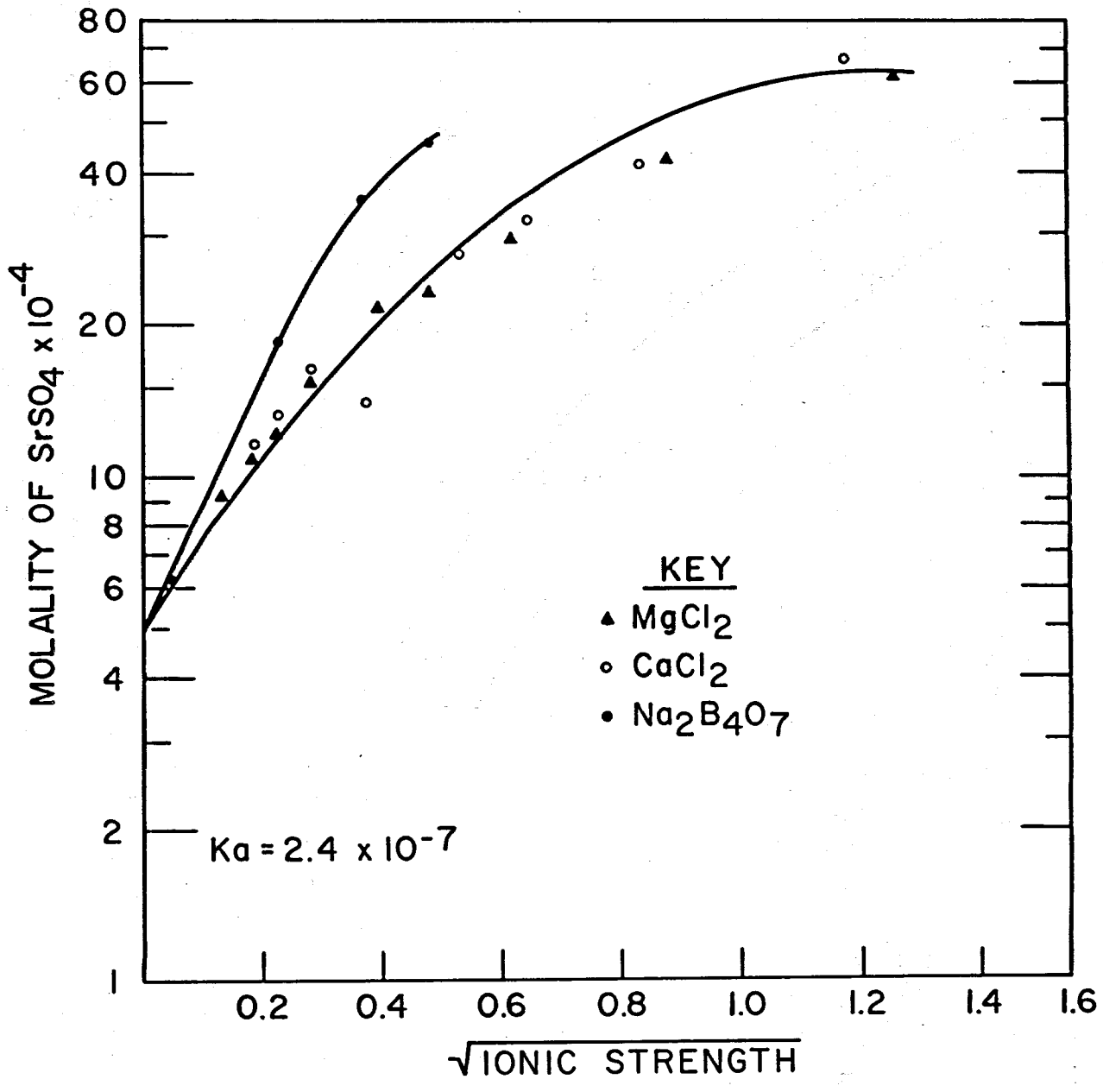
Plot of the supersaturation of a mixture of the brine shown in Table 3 with a brine containing 1,850 mg/l sulfate versus the Table 3 brine in percent



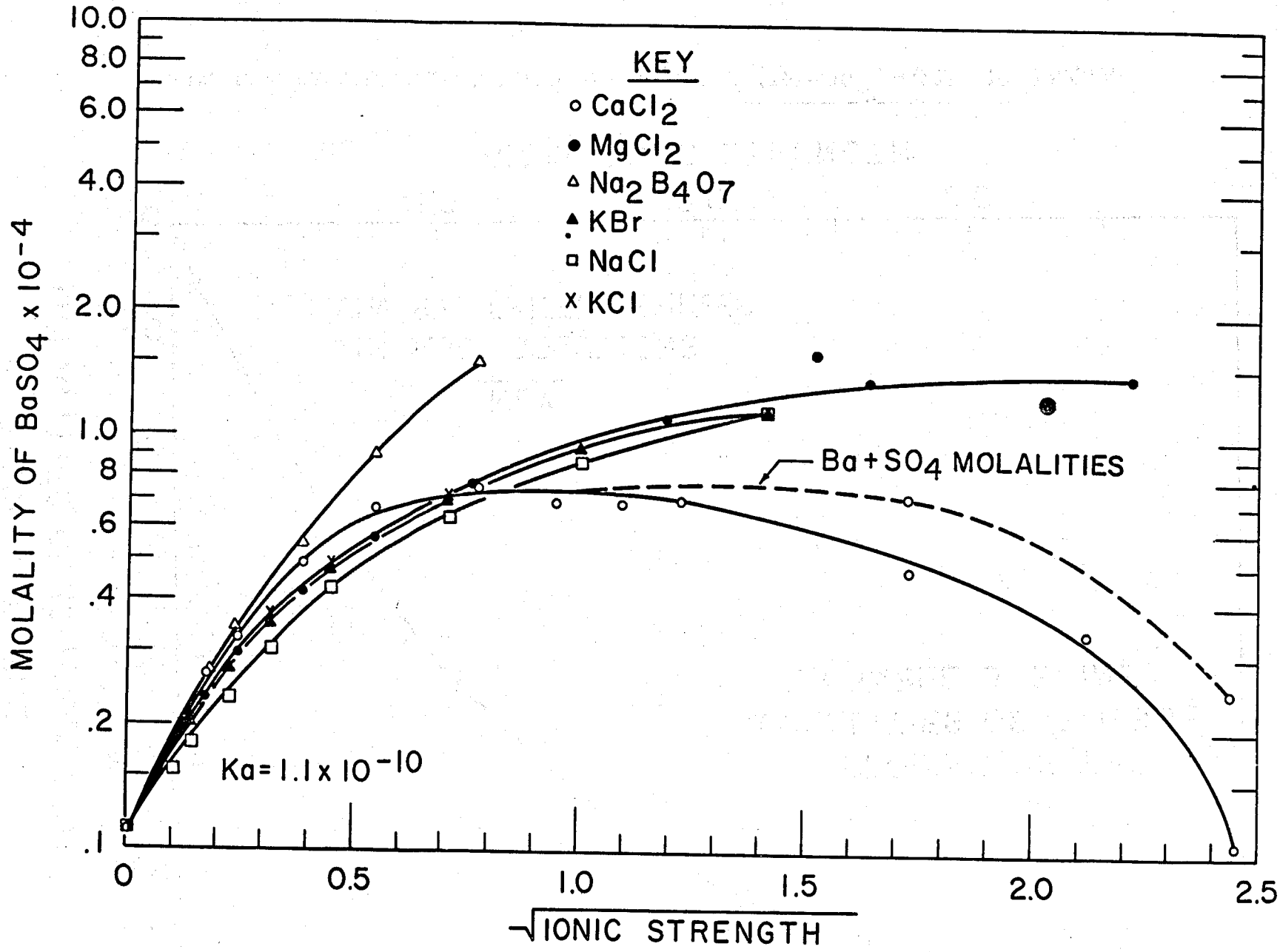
Solubility of strontium sulfate versus ionic strength of the solution



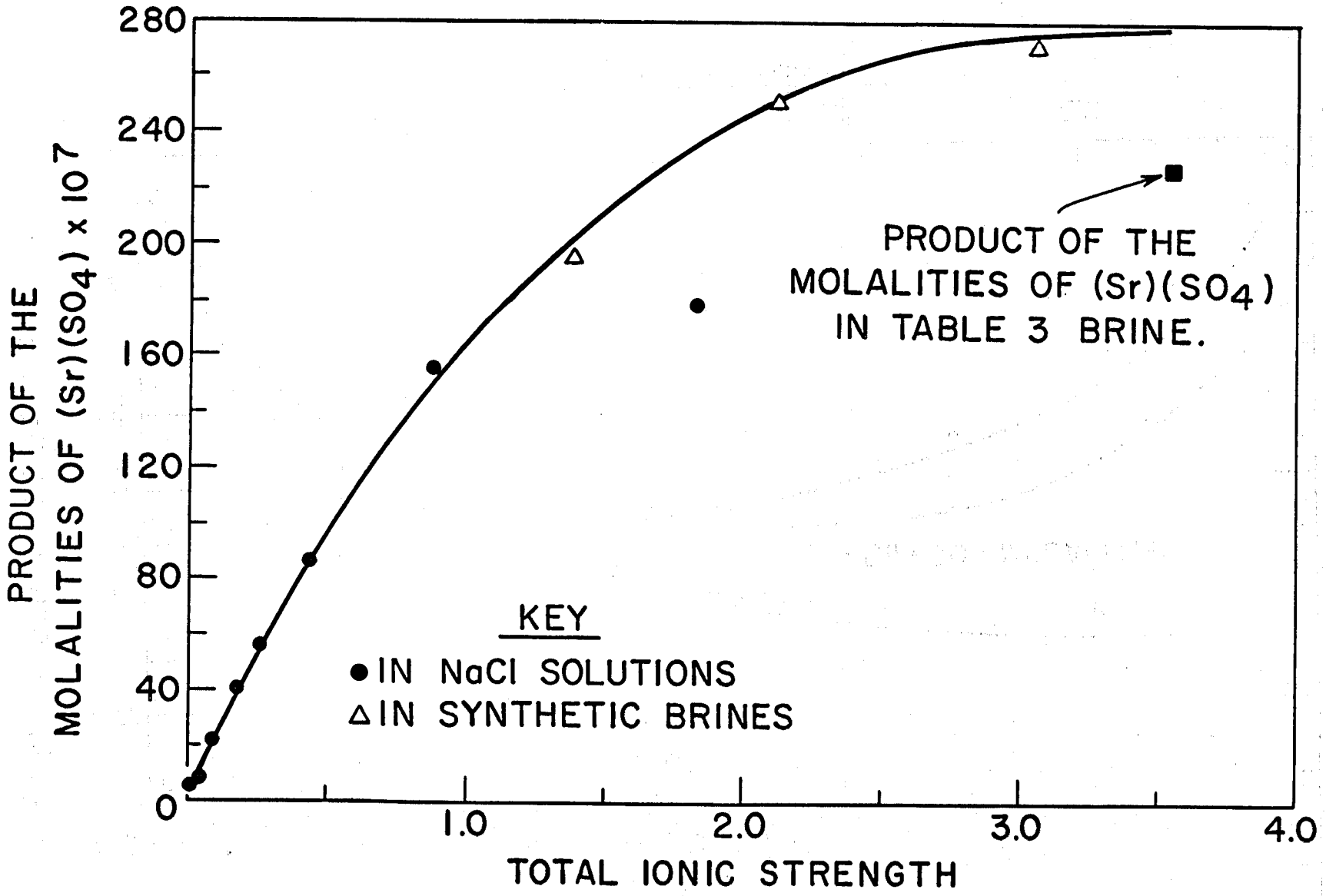
Solubility of $BaSO_4$ versus ionic strength of aqueous solutions containing $CaCl_2$, $MgCl_2$, NaCl, KCl, and KBr



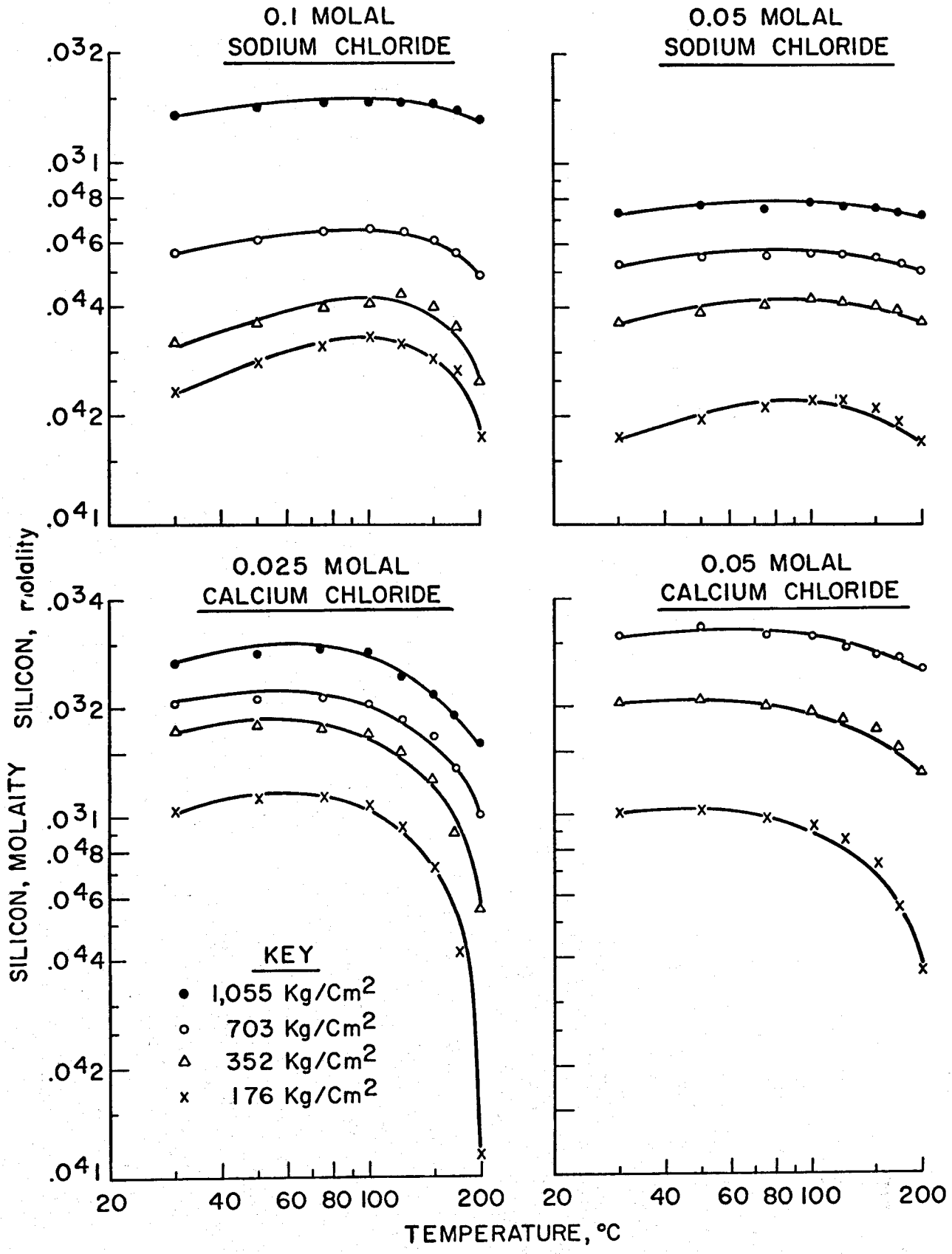
Concentrations of saturated $SrSO_4$ in strong electrolyte solutions of $MgCl_2$, $CaCl_2$, and $Na_2B_4O_7$.



Concentration of saturated $BaSO_4$ in strong electrolyte solution.



BRINE IN TABLE 3 UNDERSATURATED IN $SrSO_4$ BY $\sqrt{(280 \times 10^{-7}) - (227 \times 10^{-7})}$ MOLAL



Molal silicon solubilities from serpentine in aqueous chloride solutions at various temperatures and pressures.